U.S. Department of Energy
Energy Efficiency and Renewable Energy

biomass program

Engineering New Catalysts for In-Process Elimination of Tars

DOE OBP Thermochemical Platform Review Meeting
June 7-8, 2005

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Presentation Outline

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- **Project Background**
- **Technical Feasibility and Risks**
- **Competitive Advantage**
- **Project Overview**
- **History and Accomplishments**
- **Plan/Schedule**
- **Critical Issues and Show-stoppers**
- **Plans and Resources for Next Stage**
- **Summary**

Project Background

- FY05 Appropriated Funding
  - Contract DE-FG36-04GO14314
- Focus on Syngas R&D Platform
  - Syngas Cleanup
- Crosscutting Technology for Multiple Pathways
  - Stage Gate Commercial Track
  - Detailed Investigation
- Project Scheduled Completion 3rd Quarter FY08

Pathways and Milestones – C-level and Project Milestones

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Ag Residues **Perennial Crops** **Pulp and Paper** **Forest Products**

Validate Gas Cleanup Performance

Ag Residues	Perennial Crops	Pulp and Paper	Forest Products
M 4.11.3	M 5.11.3	M 6.2.2	M 7.1.4
M 4.12.3	M 5.12.3	M 6.3.4	

Project Milestones	Type	Performance Expectations	Due Date
Concept Feasibility	D	Make a new catalytic material that equals or exceeds the performance of NiO on olivine	September, 2005
Performance Optimization	D	Develop an optimal catalyst formulation from a refractory glass (e.g. olivine) and a well-known catalytic material (e.g. Ni)	April, 2007
Waste-Based Catalyst	D	Develop an optimal catalyst formulation utilizing a refractory, glass-based waste material (e.g. slag) as a substrate with a well-known catalytic material (e.g. Ni)	July, 2007
Determine Market Potential	D	Significantly reduce the cost of catalyst production	February, 2008
Large-Scale Test	D	Demonstrate two superior catalyst formulations – one synthesized from base compounds and one from a waste-based material in a biomass gasifier	December 2007

Technical Feasibility and Risks

The project will be successful because:

- The project is based on a **novel integration** of **existing, robust technologies** to reduce technical risk
- The **project team** combines **world-class expertise** in glass technology, catalyst research, catalyst production, and biomass gasification
- The project utilizes **compact glass-melting technology** to reduce capital and production costs
- **Existing research** points to the feasibility of this approach for producing a new type of catalyst for tar reduction in biomass gasification

Competitive Advantage

Advantages of this Approach to Catalyst Production

- Integration of current, separate manufacturing steps into one production process
- Incorporates a cost-efficient, high temperature, glass-melting technology
- Catalytic material is uniformly distributed throughout an attrition-resistant refractory glass substrate
- Ability to engineer specific properties into the glass substrate and the embedded catalytically-active material
- Low-cost of raw materials – including some negative cost waste materials

Research Program Participants

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gti

Alfred University
founded 1836

THE OHIO STATE UNIVERSITY

Research

NEXTECH MATERIALS

Commercialization

Project Objective

- Develop and demonstrate a new technology for engineering a new class of superior (cost-effective, attrition-resistant, catalytically-active) tar-cracking and reforming catalysts for use in fluidized-bed biomass gasifiers
  - Utilize compact, high-energy glass-making technology to combine catalytically-active materials (e.g. Ni, NiO, Fe, Cr) with inert, refractory glasses (e.g. olivine, engineered glasses, glassy waste materials)
  - Amenable to the economical preparation of commercial quantities of catalysts
  - Potential for extension to the design, engineering, and economical preparation of new catalysts for a variety of industrial applications

Project Activities

- Resolved contractual issues (project started ~ 4/1/05)
- Subcontracts – NexTech in place, resolving university IP issues
- Laboratory
  - Renovated catalyst testing facility. Shake-down tests in progress using naphthalene as a surrogate tar.
  - Secured samples of domestic and Austrian olivine,
  - Melting olivine, olivine-Ni and olivine-NiO mixtures
  - Refurbished an attrition resistance measurement unit (ASTM D 5757-95)

History and Accomplishments

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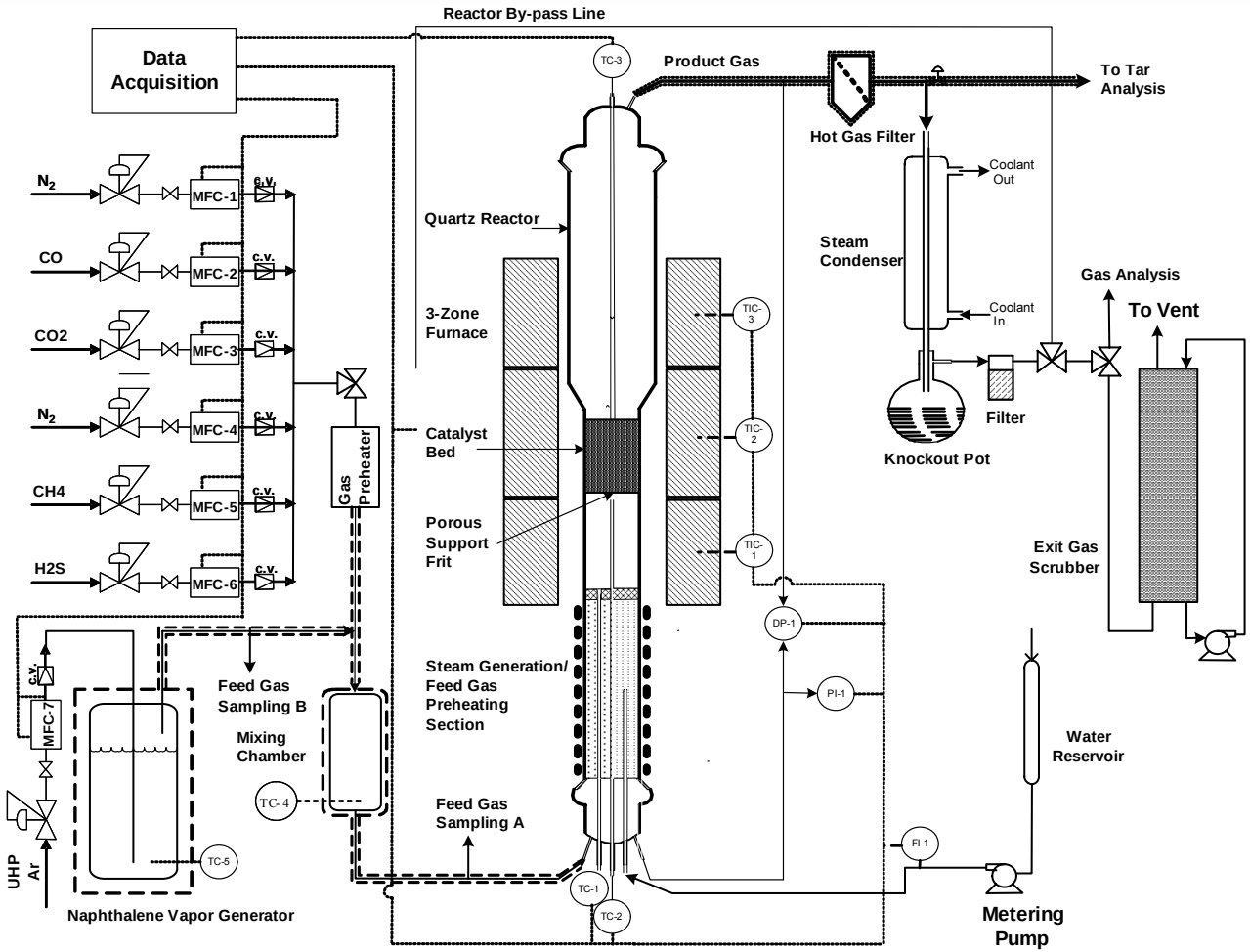
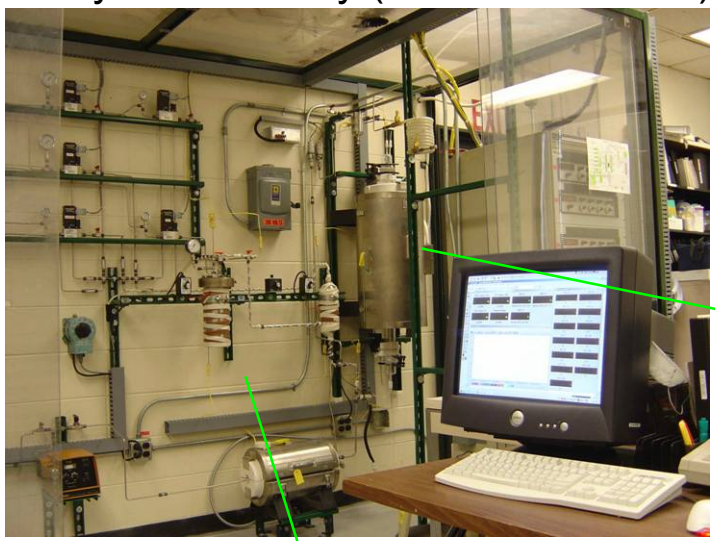


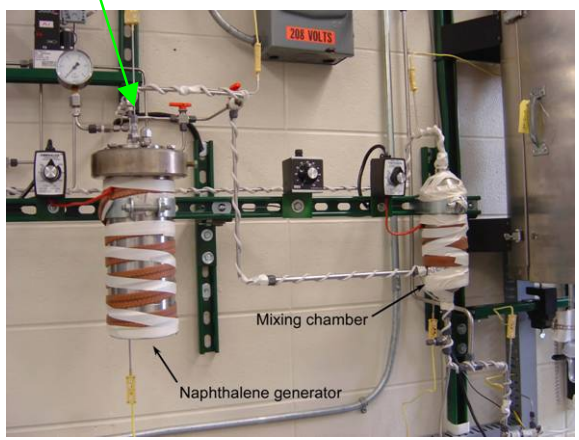
Schematic diagram of the catalyst test facility

History and Accomplishments

Catalyst test facility (before insulation)



Quartz Reactor and Oven



Naphthalene Generator

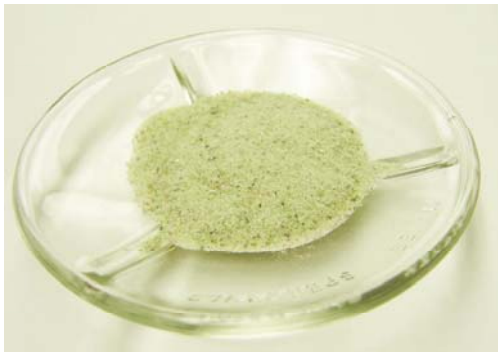
History and Accomplishments

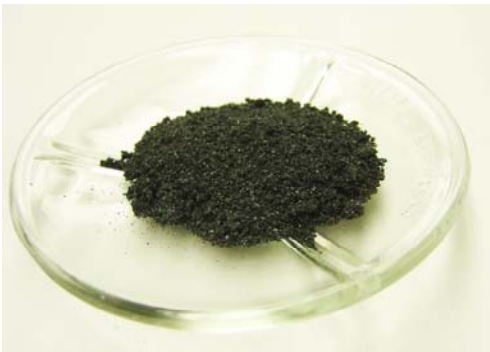
R.D. Webb 2 kW “Red Devil” furnace: 2000°C in vacuum, 2200°C in Ar

History and Accomplishments

Domestic Olivine – From Indiana, Reade, Inc.

As supplied

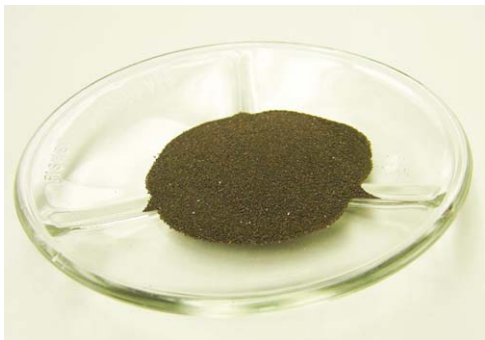




Heated to 1400°C
(in vacuum, ~2% weight loss)

Austrian Olivine – Magnolithe GmbH

Bulk



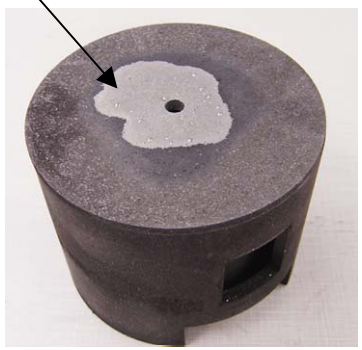
Magnolithe S-Kornungen
(sintered at ~1100°C, 0.1 – 0.3mm)

History and Accomplishments

HEATING DOMESTIC OLIVINE

Heated at 1750ºC in vacuo (13.2% weight loss)

Condensed Fe



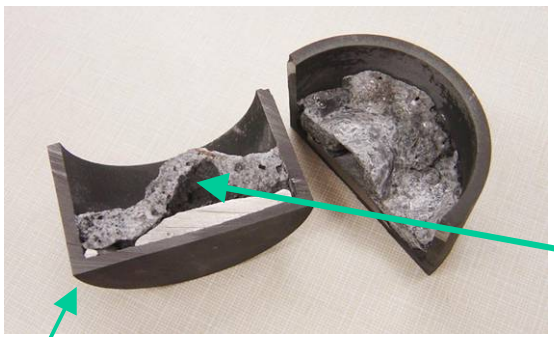
Heated at 1750ºC in Ar
(5.2% weight loss)

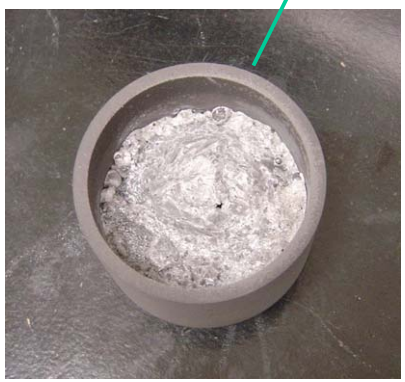
Heated at 1800ºC in vacuo (~100% weight loss)

History and Accomplishments

HEATING DOMESTIC OLIVINE WITH Ni POWDER

(First try, Ni:Olivine = 1:2)





Heated at 1760ºC in Ar, (7% weight loss)

Plan/Schedule

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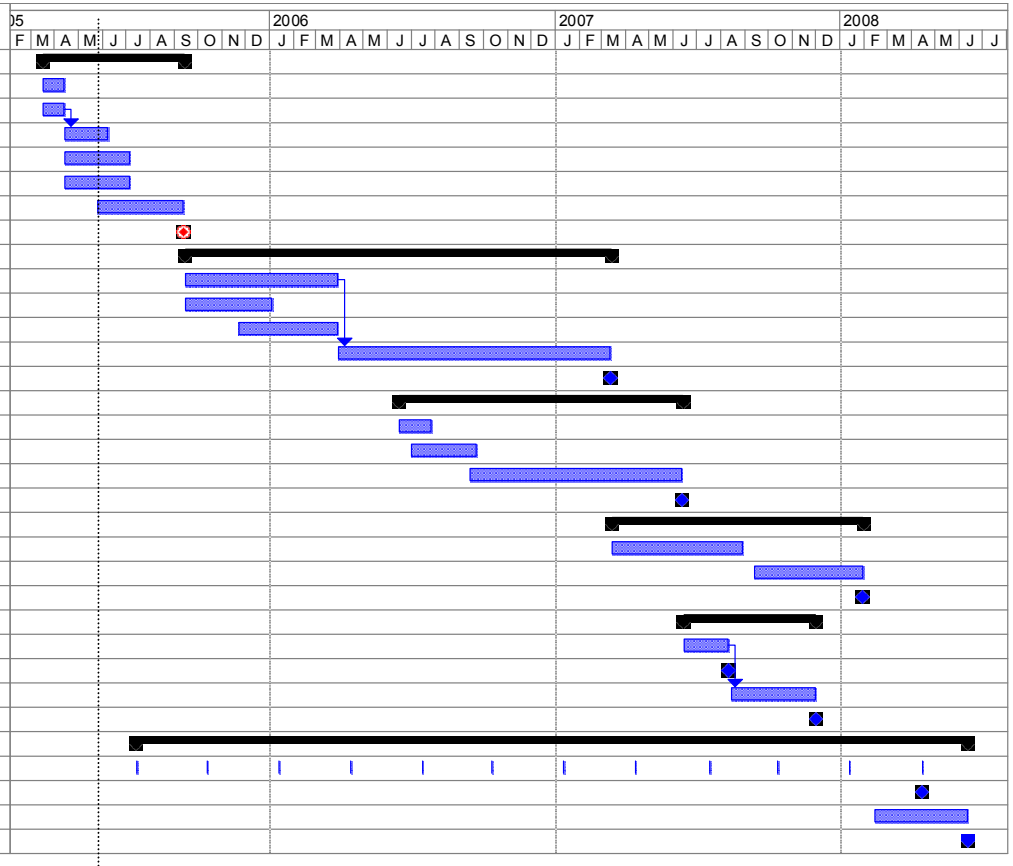
ID	Task Name
1	**Concept Feasibility**
2	Suitability of Glassy Substrate
3	Create Catalytic Material
4	Test catalyst fragments in reactor
5	Lab characterization of catalyst
6	Exploration of alternate approaches
7	Develop optimized Catalyst
8	*Go/No-Go Point - Project Continues if Task 1 successful*
9	**Optimization of Catalyst Formulation**
10	Synthesize multiple formulations
11	Synthesize and test pure fayalite
12	Compile experimental database
13	Identify and test up to 4 candidate catalyst formulations
14	*Milestone 2 - Complete Task 2*
15	**Waste-Based Catalyst Development**
16	Identify & acquire candidate materials
17	Analyze samples collected
18	Develop & test catalytic materials
19	*Milestone 3 - Complete Task 3*
20	**Techno-Economic Analysis and Commercial Assessment**
21	Assess results from Tasks 1 - 3
22	Refine Analysis with pilot-scale results
23	*Milestone 4 - Complete Task 4*
24	**Pilot-Scale Evaluation of Catalysts**
25	Produce up to two catalysts for testing
26	*Milestone 5 - Complete Catalyst Production*
27	Pilot-scale testing in Flex-Fuel facility
28	*Milestone 6 - Complete Task 5*
29	**Program Management & Reporting**
30	**Quarterly Reports**
43	*Milestone 7 - Complete Quarterly Report 12*
44	Final Report
45	*Milestone 8 - Complete & Deliver Final Report*



Project Schedule, GO14314

Critical Issues and Show Stoppers

- Synthesis of a NiO-olivine catalyst (or a similar formulation) that meets or exceeds the catalytic tar-cracking activity of NiO grafted onto olivine (by end of Task 1 – a Go/NoGo gate)

- Development of a more cost-effective technology for producing superior tar-cracking catalysts (extent to which this metric is met will be defined in Task 4).

- Production (at GTI) of sufficient quantities of up to 2 superior catalyst formulations for use as fluidizing media during pilot-scale biomass gasification tests in GTI's Flex-Fuel Test Facility (24 tons/day)

Plans and Resources for Next Stage

If it works…..

- Work with project partner NexTech Materials Ltd. to develop and market a commercial product
- Investigate extending this approach to the design, engineering, and economical preparation of new catalysts for a wide range of applications including FT synthesis, petroleum refining, SOFC syngas reforming, and non-syngas catalysis

Summary Comments

- We are still in the process of ramping up our experimental effort. However…
- Researchers in Europe are performing related R&D work, including L. Devi and Z. El-Rub (Netherlands), and C. Pfeifer (Austria) and they have been very helpful. L. Devi has provided much useful information on generating and using naphthalene as a surrogate tar. Pfeiffer is involved in pilot-scale work (at Gűssing) which is directly relevant to this project. He has provided olivine and Ni-olivine samples to us, and identified a good source for olivine.
- We submitted an abstract: "*Engineering Tar-Cracking Catalysts to Optimize Biomass Gasification*," for presentation at the 14th European Biomass Conference & Exhibition, Paris, France, October 17-21, 2005.
- An abstract: "*Engineering Tar-Cracking Catalysts to Optimize Biomass Gasification*," submitted to the 6th International Symposium & Exhibition of Gas Cleaning at High Temperature, Osaka, Japan, October 20-22, 2005 was accepted for presentation.

Budgets

DE-FG36-04GO14314

- Total project value (DOE funding): $1,949,168
- FY05 budget: $622,000 (obligated)